Why do Academics Engage with Industry? The Entrepreneurial University and Individual Motivations

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Abstract

The debate on the entrepreneurial university has raised questions about what motivates academic scientists to engage with industry. This paper provides evidence based on survey data for a large sample of UK investigators in the physical and engineering sciences. The results suggest that most academics engage with industry to further their research rather than to commercialize their knowledge. However, there are differences in terms of the channels of engagement. Patenting and spin-off company formation are motivated exclusively by commercialization whilst joint research, contract research and consulting are strongly informed by research-related motives. We conclude that policy should refrain from overly focusing on monetary incentives for industry engagement and consider a broader range of incentives for promoting interaction between academia and industry.

Keywords: University-industry relations – joint research – collaborative research – commercialization – entrepreneurial university - motivation

JEL: I23, O32

1. Introduction

The ‘entrepreneurial university’ is in vogue (Etzkowitz 2003; Slaughter and Leslie 1997). Proponents of the entrepreneurial university claim that universities are being transformed from ivory towers to engines of economic growth (Florida and Cohen 1999; Feller 1990). In similar vein, others argue that universities and industry are converging towards a hybrid order where the differences between scholarly and commercial logics are becoming blurred (Owen-Smith 2003). Policy-makers in a number of countries are promoting such developments by encouraging collaboration between universities and industry (Mowery and Nelson 2004). Implicit in many accounts of the entrepreneurial university is the assumption that academic researchers engage with industry in order to commercialize their knowledge. For this reason, policy-makers provide monetary incentives to academics to facilitate their commercial involvement (Lach and Schankerman 2008; Link and Siegel 2005).

In this paper, we investigate whether the idea of the entrepreneurial university is reflected in academic researchers’ motivations. The purpose is to present evidence on the motivational drivers underpinning various forms of engagement with industry, including informal collaboration as well as more formal engagement via patenting and academic entrepreneurship. We present results from a large scale survey of physical and engineering faculty at UK universities. We find, first, that commercialization ranks as the least important motivation for engaging with industry while research-related reasons dominate. Thus, it would seem that academics engage with industry mainly to support their academic research activities. Second, we find that the academics’ motivations differ depending on the channel of engagement. We examine classic technology transfer mechanisms, including patenting and spin-off companies, as well as collaborative and informal modes of interaction, including joint research, contract research and consulting. While patenting and spin-off founding are motivated by commercialization, collaboration is dominated by research-related motivations, including learning from industry and fund-raising.

Our analysis contributes to the debate on the entrepreneurial university by shedding light on its micro-foundations (Jain et al. 2009). Understanding the individual motivational drivers for university-industry relations is important for judging the ultimate organizational and societal implications of the entrepreneurial university (Siegel et al. 2007). Our discussion suggests that undue policy emphasis on commercialization obscures the fact that industry engagement often generates considerable benefits for academic research. We conclude that, given academics' motivations, to talk of convergence between scholarship and commerce may be premature, although interaction between these realms continues to be mutually beneficial.

Our work also contributes to the emerging body of literature on informal and collaborative modes of university-industry interaction (Link et al. 2007; Grimpe and Fier in press). While previous research has often focused on more easily measurable interactions such as patenting, licensing and academic entrepreneurship, collaboration has remained in the background, with some exceptions (Meyer-Krahmer and Schmoch 1998; Ponomariov 2008; Martinelli et al. 2008; Perkmann and Walsh 2007). To help fill this gap, we explore the drivers of informal interaction, and how they differ from interactions underpinned by intellectual property transfer, and academic entrepreneurship. Our contribution is important both conceptually and practically because collaborations constitute the majority of university-industry interactions.

The paper is structured as follows. Drawing on existing work, we outline the debate on the entrepreneurial university and show how it raises questions on academics' motivation to engage with industry. We present survey data from a sample of UK academics, which enable us to investigate their reasons for engagement with industry and, specifically, whether different channels of engagement are underpinned by different motivations. We conclude by discussing the implications of our results against the context of the existing literature, and deriving some policy conclusions.

2. Conceptual considerations

2.1. The entrepreneurial university

Universities are increasingly being called upon to contribute to economic development and competitiveness (Feller 1990) and policy-makers have put in place initiatives aimed at increasing the rate of commercialization of university technology. Notably, policy-makers implemented laws that provide commercialization incentives to universities by granting them ownership of intellectual property arising from their research. Examples comprise the 1980 Bayh-Dole Act in the US and similar legislation in other countries (Mowery and Sampat 2005; Valentin and Jensen 2007). Other policies encourage universities and firms to engage in partnerships and personnel exchange, for instance via university-industry centers or science parks (Adams et al. 2001; Siegel and Zervos 2002; Hall et al. 2000; Siegel et al. 2003). Finally, a third type of initiative seeks to build universities' knowledge transfer capabilities by supporting recruitment and training of technology transfer staff (Woolgar 2007; Kirby 2006).

While the jury on the effectiveness of some of these policies is still out (Mowery and Nelson 2004), various trends indicate a growing ambition among universities to respond to the call for a greater role in technology development, demonstrated by an increasing propensity among universities to patent (Nelson 2001; Stiglitz and Wallsten 1999), increased revenues derived from university licensing (Thursby et al. 2001), increasing numbers of university researchers engaging in academic entrepreneurship (Shane 2005), and the diffusion of technology transfer offices, industry collaboration support offices and science parks (Siegel et al. 2003).

The growing involvement of universities in technology transfer and commercialization raises questions about their nature and mission (McKelvey and Holmén 2009). Advocates of the ‘triple helix’ theory claim that universities have embraced economic and social development as a new mission, in addition to their traditional missions of teaching and research (Etzkowitz 1998). In accepting this new task, universities are said to become part of a coherent system that includes industry and government and underpins innovation and economic progress (Etzkowitz and Leydesdorff 2000). Implicit in this view is that the role of academics is shifting. Rather than concentrating on ‘blue-skies’ research, academics are seen increasingly to be eager to bridge the worlds of science and technology, in an entrepreneurial way, by commercializing the technologies that emerge from their research (Clark 1998; Shane 2004; Etzkowitz 2003).

By actively engaging in technology development, universities are demonstrating ambidexterity in their ability to produce both scientific knowledge and technology outputs (Ambos et al. 2008). For instance, in rapidly developing areas such as biotechnology, ‘star scientists’ excel both as academic researchers and academic entrepreneurs (Zucker and Darby 1996). In an analysis of the publishing and patenting activities of research-intensive US universities, Owen-Smith (2003) finds a convergence towards a ‘hybrid system’, linking scientific and technological success. Specifically, he shows that academic success drives technological invention while advantages in technological invention are driven by organizational learning relating to procedures and organizational arrangements for identifying, protecting and managing IP. Over time, positive feedback loops between the two realms lead to a hybrid order where the best universities excel in *both* scientific research and technology commercialization (Owen-Smith 2003).

Critics have responded by underlining the potentially detrimental effects of ‘entrepreneurial science’ on the long-term production of scientific knowledge, voicing fears that academic science is being instrumentalized and even manipulated by industry (Noble 1977; Slaughter and Leslie 1997; Krimsky 2003). Many universities appear to have become 'knowledge businesses' which are focused not so much on generating public goods for national audiences but providing services to specific stakeholders (McKelvey and Holmén 2009; Vallas and Kleinman 2008). The perceived risks include a shift from basic research towards more applied topics and less academic freedom (Blumenthal et al. 1986; Behrens and Gray 2001), lower levels of research productivity among academics (Agrawal and Henderson 2002) and a slowing-down of open knowledge diffusion (Nelson 2004; Rosell and Agrawal 2009; Murray and Stern 2007).

2.2 Informal collaboration with industry

Existing work investigating the features of the entrepreneurial university has primarily focused on academic researchers' engagement in patenting, licensing and academic entrepreneurship (Phan and Siegel 2006; Rothaermel et al. 2007). However, interactions between universities and industry take multiple forms, with interaction channels ranging from inter-organizational relationships (e.g. joint research or contract research) to spin-off companies, to IP transfer including patenting and licensing (Carayol 2003; D'Este and Patel 2007; Bonaccorsi and Piccaluga 1994; Schartinger et al. 2002; Cohen et al. 2002; Bercovitz and Feldman 2006).

Among these channels, engagement in *collaboration* is far more frequent than engagement in patenting and academic entrepreneurship (D'Este and Patel 2007; Perkmann and Walsh 2007). There are three main forms of collaboration. *Collaborative* (or joint) *research* refers to formal collaborative arrangements aimed at cooperation on R&D projects (Hall et al. 2001). In many cases, the content of this research can be considered 'pre-competitive', and these projects are often subsidized by public funding. *Contract research*, on the other hand, refers to research that is directly commercially relevant to firms and, therefore, is usually ineligible for public support. Contract research is explicitly commissioned by firms and the work is usually more applied than in collaborative research arrangements (Van Looy et al. 2004). Finally, *consulting* refers to research or advisory services provided by individual academic researchers to their industry clients (Perkmann and Walsh 2008). Consulting projects are typically commissioned directly by the industry partner and the income derived from them often accrues to individuals although it can be channeled through university research accounts to support research. Some of the above types of collaboration have been referred to as 'informal' collaboration (Link et al. 2007) even though most of these arrangements tend to be formalized via contracts. In this paper, therefore, we use the terms 'collaboration' or 'collaborative forms of interaction' to include collaborative research, contract research and consulting.

Collaboration is not only more frequently used than IP transfer and academic entrepreneurship but it also tends to be more highly valued. Research suggests, for instance, that the role of IP transfer in transferring knowledge is modest (Agrawal and Henderson 2002). In many cases, faculty do not disclose inventions to their university, and hence these are unaccounted for by studies focused on IP (Siegel et al. 2003). Roessner (1993), drawing on survey evidence relating to different interaction channels, finds that US research and development (R&D) executives place the highest value on contract research, followed by co-operative research while they see licensing as less relevant. Similarly, according to the Carnegie Mellon Survey, US R&D executives regard consulting, contract research and joint research as more relevant channels than licensing (Cohen et al. 2002). These finding are confirmed by a number of other studies (Klevorick et al. 1995; Mansfield 1991; Pavitt 1991; Agrawal and Henderson 2002; Schartinger et al. 2002).

Having established the empirical significance of collaborative forms of interaction, the question arises how they relate to the idea of the entrepreneurial university. On one hand, it could be argued that collaborative forms of engagement constitute just another, less formalized form of technology transfer that is governed by dynamics similar to patenting and academic entrepreneurship. Increasing collaborative involvement may therefore be consistent with a scenario where academic researchers adopt industrial logics and become active participants in technology development and commercialization (Etzkowitz 1998).

On the other, collaboration may be governed by a logic that differs from the idealized norms of the entrepreneurial university. In this scenario, collaboration would be informed by the traditional values of the scientific system as elaborated by Merton (1973) and Polanyi (2000 [1962]). Collaborative engagement with industry may benefit academics' research activities by establishing relationships with knowledge users and mobilizing resources that complement public research funding. In many disciplines, interaction between the producers of scientific knowledge and producers of technology underlies the progress of both science and technology in a recursive way (Rosenberg 1982). Even though science may not be immediately applied, it is often nevertheless inspired by practical considerations and hence benefits from interactive contact with technology producers (Stokes 1997). Benefits from industry cooperation include securing funds for graduate students, accessing laboratory equipment, gaining insights applicable to academic research, and supplementing research monies (Mansfield 1995; Murray 2002).

In this paper, we seek clarification on the nature of collaboration by exploring academic researchers' *motivation* to engage in it, as compared with the more overtly commercial forms of entrepreneurial behavior.

2.3. Why do academics engage with industry?

Universities are professional bureaucracies whose members are relatively free to pursue activities that they believe are in the overall interests of the organization (Mintzberg

1983). Contrary to teaching, engaging with industry constitutes discretionary behavior for academics. Many universities have formal policies for encouraging their academic staff to seek industry assignments for a specified share of their time (Perkmann and Walsh 2008). Royalty sharing policies at many universities provide incentives for the disclosure of inventions to the university administration (Bercovitz and Feldman 2008) and subsequent participation of inventors in product development efforts via spin-off companies or licensing (Lowe 2006).

Deployment of these incentive mechanisms presupposes that academic researchers respond to financial incentives tied to successful commercialization of their ideas (Jensen and Thursby 2001). This logic is implicit in life cycle theories that maintain that junior researchers focus on building reputation in academia while later in their careers they capitalize on their expertise by reaching out to industry (Stephan and Levin 1992; Zuckerman and Merton 1972). A qualitative study by Owen-Smith and Powell (2001) provides some support for the idea that academics are attracted by monetary profit. The authors find that in the life sciences – where patents have higher monetary value – researchers patent to enhance their incomes. In the physical sciences, on the other hand, patenting is less attractive because of lower monetary pay-offs and therefore is pursued primarily to develop relationships with firms, access equipment or exploit other research-related opportunities (Owen-Smith and Powell 2001).

However, other contributions suggest that working with industry is not necessarily underpinned by entrepreneurial intentions in the sense of responding to economic opportunities. Bercovitz and Feldman (2008) find that faculty members' compliance with entrepreneurial behavior can be substantial or symbolic. Only under certain conditions – e.g. presence of local entrepreneurial norms - do academics engage in substantial entrepreneurial behavior as opposed to superficial compliance. A study of German academic researchers demonstrated that researchers engage in patenting not for personal profit but to signal their achievements and gain reputation amongst their academic and industry-related communities (Göktepe-Hulten and Mahagaonkar 2009).

Research on *attitudes* to academic entrepreneurship present a differentiated picture. Data on US universities indicate that most academics, particularly in engineering and the applied sciences, are keen on technology transfer activities, but less so on overly commercial schemes such as start-up assistance to new technology firms, and equity investment (Lee 1996). Faculty in high ranked institutions are less in favor of academic entrepreneurship than academics at lower tier universities. The main concern of academics is that industry involvement might restrict academic freedom, i.e. the ability to pursue curiosity-driven research without having to consider commercial gain (Lee 1996). However, academics appear to draw boundaries between the forms of industry engagement they see as legitimate, and others that they view as overly commercial (Lee 1996). In any case, academics express significant support for industry collaboration particularly when it is related to their research (Lee 2000). A meta-study shows that academic researchers' attitudes to financial ties with industry sponsors are largely positive, especially when funding is indirectly related to their research, disclosure is agreed upfront, and ideas are freely publicized (Glaser and Bero 2005). A study of German academic researchers in four disciplines suggests that acquiring additional research funds and learning from industry constitute the main motives for engaging with industry (Meyer-Krahmer and Schmoch 1998).

Our review of the literature on academics' motivation for engaging with industry reveals discordance between two groups of authors. While a first group emphasize academics' utility-maximizing commercialization behavior, others find that academics operate in a strongly institutionalized environment sporting science-specific norms and values. In the view of the former group, academics collaborate with industry to pursue commercialization while the latter believes that, rather than being entrepreneurs, academics collaborate with industry primarily to support their research. Our goal in this paper is to help clarify which of the above views is accurate and which type of collaboration is driven by commercialization behavior and research-driven behavior, respectively.

We present results from a unique dataset, collected from physical and engineering science faculty at UK universities, which is distinct in two ways. First, instead of providing evidence on academics' attitudes, we present data on academics' motivation to engage in actual collaboration. Previous, attitudinal, studies provide respondents' views about industry engagement, but do not connect them with actual collaboration (Lee 1996; Glaser and Bero 2005). Second, we have motivational data on a whole range of different forms of interaction, allowing us to draw a comparison between the classic modes of commercialization (patenting, academic entrepreneurship) and more informal collaboration modes. Many existing studies provide evidence only on specific types of academic industry involvement, with a number of contributions investigating academics' motives for engaging in patenting (Owen-Smith and Powell 2001; Moutinho et al. 2007; Baldini et al. 2007).

3. Data and main variables

3.1. Sample and data collection

Our data are derived from a large-scale survey of university researchers aimed at obtaining information on their interactions with industry. The sample was compiled from the record of research grants holders from the UK's Engineering and Physical Sciences Research Council (EPSRC) between 1999 and 2003. The EPSRC provides research funding mainly to university-based investigators based on applications submitted in response to open calls. It distributes 20-25% of the total UK public science budget. The EPSRC actively encourages partnerships between researchers and the potential users and beneficiaries of research, such as industry, government, National

Health Service (NHS) trusts and non-profit organizations. Almost 45% of EPSRC-funded projects involve partnerships with industry or other stakeholders.

To ensure our sample was representative of the population of researchers in the physical and engineering sciences, we excluded disciplines whose researchers might be likely to apply to other research councils. The ten disciplines considered in our study are: Chemical Engineering; Chemistry; Civil Engineering; Computer Science; Electrical and Electronic Engineering; General Engineering; Mathematics; Mechanical, Aeronautics and Manufacturing Engineering; Metallurgy and Materials; and Physics. The sample includes 4,337 researchers, corresponding to approximately 42% of the population of active researchers in our target disciplines.[1]

The survey was administered by post in 2004 and generated 1,528 valid questionnaires, a response rate of 35.2%. Our tests for response bias indicate that there are no statistically significant differences among response rates across scientific disciplines.[2] However, there are statistically significant differences with respect to certain individual characteristics, including the proportion of respondents and non-respondents holding collaborative grants over the period 1991-2003 (57% and 53% for respondents and non-respondents, respectively), and being a professor (44% and 39% for respondents and non-respondents, respectively). Overall, though, response rate biases are relatively minor and unlikely to affect the results.

The questionnaire contained questions on various aspects of industry engagement.[3] Our analysis is based on two sets of information: a) the frequency of engagement with industry through five channels and b) the respondents' rationales for engagement with

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[1] According to data from the UK 2001 Research Assessment Exercise (RAE)

[2] Response rates (number of valid returned questionnaires relative to population surveyed) by discipline: Chemical Engineering, 35.6%; Chemistry, 35.9%; Civil Engineering, 35.5%; Computer Science, 30.2%; Electrical & Electronic Engineering, 34.7%; General Engineering, 39.7%; Mathematics, 38.4%; Mechanical, Aeronautical & Manufacturing Engineering, 36.9%; Metallurgy & Materials, 34.2%; and Physics, 32.7%.

[3] See D'Este and Patel (2007) for a detailed description.

industry. We analyzed our data via ordered logit regressions, using engagement in various types of channels as the dependent variables.

3.2. Dependent, explanatory and control variables

Dependent variables

We consider five dependent variables, each representing frequency of industry engagement via a specific channel: joint research agreement, contract research agreement, consulting, spin-off company establishment, and patenting. Respondents were asked: 'How frequently were you engaged in the following types of activity in the calendar years 2002 and 2003?' They were given a choice of five intervals: 0, once or twice, 3 to 5 times, 6 to 9 times, and 10 times or more.[4] Based on responses, and given that activity was strongly concentrated in the first two interval categories, we defined our dependent variables as ranging between 0 and 2, 0 if the researcher had no involvement for a type of activity, 1 for one or two instances, and 2 if the researcher engaged three or more times in an activity (see descriptive statistics in Table A1 in the Appendix). There is little overlap among these channels, while there is positive and significant bivariate correlation between each pair; Spearman correlation coefficients range from 0.12 to 0.34. Since our dependent variables are discrete and ordered, we use ordered logit models for our estimations.

The three channels with the highest proportion of researchers engaging at least once are: contract research, joint research, and consulting. More than 50% of respondents indicated using each of these channels at least once in the period analyzed.

Explanatory variables

Academics' motivations for engaging with industry constituted our explanatory variables. We built them from the responses to the following question in the survey:

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[4] However, for patents, respondents were requested to report the actual number of patent applications.

‘Please rank the following reasons for your involvement in interactions with industry according to their importance’ (see Table 1). Respondents were asked to score the importance of each item on a five-point Likert scale, ranging from ‘not important’ (1) to ‘extremely important’ (5). We carried out a factor analysis (principal component analysis - PCA) on the 12 items to determine whether they corresponded to more general, underlying rationales for engagement with industry. We then used these factors – which we called ‘motivations’ – as explanatory variables (see Table A2 in the Appendix for descriptive statistics).

Specifically, we regressed each of the dependent variables on the extent to which respondents assessed each motivation as important. We measured the importance attributed to a specific motivation by taking the average score of respondents’ assessment of the importance of the single incentive items that composed each motivation. For instance, if one factor comprised four items, the average score refers to the average of these four incentive items. Since each item in the questionnaire was ranked on a five-point Likert scale, our measure for each motivation ranges between 1 and 5; the higher the number, the higher the importance attached to a specific motivation.

Control variables

We used a number of control variables reflecting the characteristics of individual university researchers and their organizational environments. We aimed to control for individual experience and career-stage effects through the following variables: a) extent of previous involvement with industry, measured by *number of joint publications with industry* in the period 1995-2000, and *average value of collaborative EPSRC grants* (i.e. with industry) obtained by the researcher between 1995 and 2001;[5] and b) researcher’s *age* and *academic status* (i.e. whether the researcher is a professor or not).

[5] Both variables log transformed.

Our organization-level control variables include the impact of department size, the composition of departmental research funding, and research quality of the institution. Previous research shows that these organizational characteristics could have an impact on the extent to which researchers engage with industry (Belkhodja and Landry 2007; Schartinger et al. 2002; Tornquist and Kallsen 1994; Feldman et al. 2002). We considered the following variables: a) size of the department to which the researcher is affiliated (measured by average number of full-time equivalent staff for the period 1998/99-2000/01); b) volume of research funding at department level, including *volume of research income from contracts with industry per member of staff*, and *volume of research income from public sources per member of staff* over the same period (both indicators refer to the period 1998/99-2000/01);[6] and c) departmental *research quality* proxied by the 2001 UK RAE rating. We use dummy variables to identify departments with the highest score (5*) and departments ranked lower than five, using point five as the reference category.[7] Finally, we include scientific discipline and regional dummies to control for differences across scientific fields and geographic location in terms of researchers' propensities to engage with industry. Some of information underpinning the control variables is from non-survey sources, such as records of previous collaborative grants, joint publications, or RAE research rankings, in order to alleviate some common method bias.

3.3. Control for selection bias

Only respondents reporting engagement with industry (1,088 individuals - 71% of 1,528) were asked about their motivations. Because this risks introducing selection bias

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[6] Data on department finances and staff numbers are from www.hesa.ac.uk. Variables for industry and public research funding, and number of staff, were computed at department level as averages for the academic years 1998-99 and 2000-01. Public research funding refers to funding for research from any of the UK research councils. Finance data are in £'000. All variables log transformed.

[7] The choice of these three categories is based on the fact that the reference category accounts for a large proportion of departments: three categories produces a more even distribution of departments. Information on UK RAE 2001 is from: www.hero.ac.uk.

since we do not account for why researchers decide to engage with industry, we use a two-stage regression model, drawing on Manning et al. (1987). In the first stage, we ran a logit model with the dependent variable for whether a researcher engaged with industry or not. We included five control variables to capture perceived barriers to engaging with industry, and some individual and departmental features; information was available from all 1,528 respondents for all these variables.[8]

From this model we calculated the predicted probability for each individual to engage with industry. We then ran a second stage model for individuals who engaged at least once, but controlled for selection bias by including the predicted probabilities of interaction from the first stage model (variable name: prob.). In the second stage, we used frequency of engagement in the various channels as defined above (section 3.2) as dependent variables, in ordered logit regressions.

4. Results

4.1. Taxonomy of motivations for engaging with industry

Table 1 presents descriptive results for the different incentive items, broken down by discipline, to indicate the proportion of respondents assessing an item as very or extremely important (i.e. scores of 4 or 5).

Insert Table 1 about here

Two issues emerged. First, there is significant variation in terms of which incentive items researchers deem to be important. While 74.5% of researchers rated 'applicability

[8] The 5 variables related to barriers are dichotomous variables which take the value 1 if the respondent assessed the barriers as very, or extremely important. The 5 barriers are: absence of established procedures to collaborate with industry; nature of my research not aligned with industry interests or needs; potential conflicts with industry regarding royalty payments from patents or other IP rights; short term orientation of industry research; and rules and regulations imposed by university or government funding agency. The results of the first-stage logistic regressions are available on request.

of research' as highly important, only 11.1% rated 'seeking IP rights' similarly. Also, 'access to personal income' was considered important by only 16% of academics, indicating that pecuniary gains were far less significant than other reasons for working with industry.

Second, there was variation across disciplines, with some notable differences such as those between engineering, and chemistry, computer science, mathematics and physics. Across the engineering fields, there are few statistical differences in terms of incentives ranked by researchers as important.[9] Significantly fewer researchers in mathematics and chemistry assessed items as important compared to the overall sample. Computer scientists and physicists occupied an intermediate position, since for approximately half of the items, proportions were not statistically different from those prevailing in the engineering fields.

A factor analysis conducted on the 12 items resulted in four factors (Table 2). The first comprises five items, all related to expectations related to learning opportunities from engagement with industry. We labeled this 'learning' motivation. The second factor, which we labeled 'access to in-kind resources', reflects keenness to access resources, such as materials, research expertise and equipment. The third factor is related to expectations about 'accessing funding' for research. The fourth factor, which we labeled 'commercialization', reflects expectations of personal economic returns (PCA results are reported in Table A3 in the Appendix).

Insert Table 2 about here

A first evaluation of these results reveals that three motivations, i.e. learning, access to-

[9] The two items where there were significant differences across engineering fields are: 'feedback from industry' and 'access to equipment'.

in-kind resources, and access to funding, are related to supporting academics' research and only commercialization is related to deriving economic benefit from the research. We look at the implications of this finding in the discussion section.

4.2. Relationship between types of motivation and channels of interaction

Having identified four independent motivations for academics to engage with industry, we conducted a regression analysis to examine the impact of these motivations on engaging in different channels of interactions.

Table 3 presents the results for the relationship between frequency of interaction via five channels, and researchers' ranking of the importance of the four motivations. We find that motivations have a distinct influence on the frequency of interactions across engagement channels. The learning motivation is positively associated with higher frequencies of industry engagement across several channels, i.e. joint research, contract research and consulting, all of which are based on relationships involving personal contacts with industry partners.

Insert Table 3 about here

Commercialization as a main motivation is positively associated with spin-off company activity, consulting and patenting, but shows no significant relationship with frequency of engagement in any of the other channels. Researchers who regard access to funding as particularly important engage more frequently in joint research, contract research and to some degree, consulting, although this last is only weakly significant. In contrast, high importance of access to in-kind resources has a negative effect on the frequency of engagement in contract research, consulting, spin-offs and patenting, and no significant impact on joint research.

Finally, with respect to our control variables, these results show that, ceteris paribus, experience in collaborative research increases the probability of more frequent collaboration via several channels. While being a professor has a positive impact on engagement frequency (with the exception of spin-off company activity), being a young researcher has a positive impact on the frequency of engagement in joint research and consulting. Researchers in lower-rated research departments tend to do more consulting compared to researchers in high ranked departments, while researchers in departments with higher ratios of per capita research income from industry are particularly likely to engage in more frequent contract research. We also found some variation across disciplines. For instance, while chemists are less likely to engage in contract research and consulting compared to mechanical engineers, they are more likely to patent.

To confirm the robustness of our results, we conducted analyses using different constructions for the dependent variables. For instance, we devised dichotomous dependent variables and ran probit and logit regressions. The results are similar to those in Table 3. Also, since interaction via one channel may not be independent of activity via another, we conducted multivariate probit analysis to capture possible interdependencies among different channels, based on the STATA routine proposed by Cappellari and Jenkins (2003). Table A4 in the Appendix reports the results for the multivariate probit model, which are in line with those in Table 3.

As our information is drawn from a survey, the results do not provide ultimate answers about the direction of causation. However, conceptually, we would argue that it is more likely that motivation determines the frequency of engagement than vice versa.

5. Discussion

In this paper, we investigate what motivates academics to engage with industry using both informal collaboration and formal models of interaction. We identified four main motivations: (i) *commercialization* (commercial exploitation of technology or knowledge); (ii) *learning* (informing academic research through engagement with industry); (iii) access to *funding* (complementing public research monies with funding from industry); and (iv) access to *in-kind resources* (using industry-provided equipment, materials and data for research).

Three of these factors are research-related; only one is related to an intention to be entrepreneurial. In fact, our results suggest that most academics engage with industry in order to further their own *research*, either through learning or through access to funds and other resources. In addition, commercialization on average was ranked lowest by our survey respondents (Appendix Table A2).

While the desire to raise funds for research is intuitively appealing, the learning motivation requires clarification. The items related to the 'learning' motivation refer to the expected benefits from gaining new insights, receiving feedback on research, and accessing new knowledge through engagement with industry. These benefits are likely to arise from an important yet often under-appreciated aspect of public research, i.e. backward linkages from applied technology. For instance, resolving problems that occur in technology development can lead to follow-on research activities, inform academic research agendas and in some cases even lead to new scientific disciplines (Rosenberg 1982). Mansfield (1995) observes that the problems that many academics choose to work on are often inspired by their consulting activities. Also, a significant share of basic public research is associated with 'Pasteur's quadrant', i.e. is driven by the pursuit of basic understanding and considerations of use (Stokes 1997). Much research in biotechnology, computer science, aeronautical engineering and other disciplines conforms to the Pasteur logic. It involves an intrinsic affinity between academic and industry research, which has implications for academics' motivations for choosing to interact with industry. Thus, whenever researchers engage in research that is driven by considerations of both basic understanding and use, the 'learning-based' logic for interaction is likely to be prevalent.

We also find that engagement in different forms of interaction is underpinned by varying motivations. Academics motivated by learning frequently engage in joint research, contract research and consulting, while motivations related to commercialization of research lead to engagement in activities such as patenting, spin-offs and consulting. It should be borne in mind, however, that patenting and involvement in spin-off companies are relatively rare compared to involvement in collaborative forms of interaction. Only around 17% of the respondents who engaged with industry participated in spin-off companies, and approximately 30% reported filing patents.

The channels of engagement underpinned by research-related motivations, particularly learning and access to funding, are all based on direct collaboration with industry partners, which suggests that academic research interests benefit most from highly interactive, 'bench-level' relationships with industry users. The fact that 'access to in-kind resources' is negatively related to most forms of interaction requires further comment. As joint research is not affected by this relationship, it appears that, particularly the more commercial forms of interaction are rarely *directly* conducive to carrying out academic research. For instance, data derived from consultancy work or contract research may not be sufficiently novel for publication. However, these direct effects tend to be outweighed by indirect benefits, such as learning and access to research funding. Learning is an indirect benefit in that industry projects may not lead directly to novel scientific outputs, but may lead to new research problems and learning about new industrial applications (Perkmann and Walsh 2009). Access to funding is also an indirect benefit as it may facilitate economies of scale and retention of staff at university laboratories.

It would appear from our results that there is a tension between commercialization and research-related motivations. While patenting and spin-off involvement are driven by commercialization, the more collaborative forms of interaction are driven by research-related motivations, but not commercialization. For patenting and spin-off involvement, our results confirm the basic premise of the entrepreneurial university. Academics engage in these activities because they are interested in deriving personal pay-offs from the commercialization of their knowledge and technologies. However, they do not appear to derive significant *research*-related benefits from this entrepreneurial behavior. The reverse applies to collaborative forms of interaction: the motivations for joint research and contract research are clearly research-driven and commercialization plays no role.

Consulting is an exception to this pattern in that it is driven by both commercialization and research-related motivations. Consulting is 'polyvalent' as it allows academics to pursue personal income in an entrepreneurial manner (Louis et al. 1989), and to build personal relationships with industry practitioners and learn about industry problems and applications. Provision of consultancy, therefore, would be attractive for researchers who are driven by learning motivations (Mansfield 1995; Murray 2002). Thus, consulting may constitute the 'boundary' to university-industry collaboration (Lee 1996) in the sense that it marks the limits to what constitutes research-relevant involvement with industry. So, while joint research, contract research and consulting are conducive to academic output, involvement in patenting and academic entrepreneurship may not generate similar complementarities with research.

In terms of policy, our results suggest a cautious approach to undifferentiated attempts to promote the entrepreneurial university. Many policy measures emphasize commercialization as the central mechanism for rendering university knowledge relevant to economy and society. These include the Bayh-Dole Act in the US and similar legislative initiatives in other countries, as well as governments' attempts to increase 'third stream engagement' in universities through subsidies for technology transfer offices (Mowery and Sampat 2005; Czarnitzki et al. 2009). Data on disclosures, patenting, licensing and spin-offs are often used as metrics for assessing universities' technology transfer efforts. These types of policy measures are based on the principle that universities seek to protect their IP and exploit it in the industry market place. As the proceeds from the commercialization of IP are usually shared between the university and the individual academic inventor(s), the financial incentive is seen as encouraging academic involvement in technology transfer (Lach and Schankerman 2008).

If, on the other hand, academics engage with industry mainly to further their research, reliance on academics' entrepreneurial behavior appears misplaced. This is reinforced by the fact that the intention of policy-makers is not necessarily to maximize universities' income, but rather to make technology available to firms and society at large. Also, universities' efforts to reap significant income from commercialization are generally unsuccessful as the proceeds from licensing are usually decimated by the costs of patenting and maintaining technology transfer offices (Thursby et al. 2001). This means universities should be encouraged not to privilege a narrow remit of technology transfer offices as champions of IP protection and incubators for spin-offs as this kind of interaction might be misaligned with most academics' motivations for working with industry. As our results show, academics generally view collaborative engagement with industry as beneficial to their research and, given that industry pays for much of this interaction, it could be assumed that industry partners also judge it to be useful (Gulbrandsen and Slipersæter 2007). Universities therefore should integrate their monetary incentive schemes for commercialization with general policies enabling and encouraging collaboration with industry more generally. Conceptually, the ultimate implication of our findings is that – in the setting of university-industry relations – the locus of economic opportunity recognition will in most cases lie with industry partners commissioning contract research and consulting rather than academic researchers pursuing academic entrepreneurship. This means most – but not all – academics are motivated by finding solutions to interesting problems rather than pursuing economic opportunities.

Our paper has some limitations, raising questions for future research. The data for our analysis are drawn from the physical and engineering sciences only. The life sciences are generally characterized by a high intensity of university-industry relationships (Powell et al. 1996) and responses from life science researchers could provide a different picture of the motivations underpinning IP transfer. However, results from the large body of existing research on the life sciences may have been generalized too readily and further research should investigate other disciplines. Furthermore, our results need to be validated by research using alternative approaches to sampling. As our sample was constructed from the records of academics who received government grants, there may be a bias towards particularly successful and/or comparatively senior researchers and against researchers who may have received industry funding only.

Another avenue for further research is to examine the effects of different channels of interaction for the direction and quality of research conducted by academic researchers. Our results suggest that the impact on academic research of industry engagement may differ according to the motivations driving interactions. When academics work with industry primarily to further their research, negative impacts on the direction of their research or on their research productivity will be arguably less likely. This holds particularly when academics are motivated by learning and access to resources. Our data suggest that this type of collaboration is less likely to result in immediately commercially relevant outputs, such as patents and spin-offs. At the same time, however, in the longer term, engagement in relationship-intensive collaboration with companies might enhance academic research output and generate university benefits via better research evaluations and higher levels of funding. Future research should seek to provide more informed judgment on the potential benefits and drawbacks associated with the different channels of engagement with industry used by academic researchers.

6. Conclusion

Our results suggest the vision of entrepreneurial university fails to neatly capture the complex nature of academic researchers' interactions with industry. Rather than a 'hybrid order' in which universities and industry converge to become common drivers of technological and economic development, most academic researchers are keen to retain their autonomy by ensuring that collaborative work with industry is conducive to – or at least compatible with – their research activity. This suggests that, for universities, the benefits of university-industry collaboration are best attained by cross-fertilization rather encouraging academics to become economic entrepreneurs. Collaboration is fruitful when it facilitates or contributes to both industry applications and academic research. Such collaboration retains the distinctiveness of the realms of scholarship and industry, but enables connections via interactive links that allow academic input to commercial problems and promotion of new ideas and new problems for university research (Rosenberg 1982; Stokes 1997). Announcements of the entrepreneurial university may therefore be premature and based on an overstated generalization of insights from the life sciences (see e.g. Owen-Smith and Powell 2001). Our analysis of the physical and engineering sciences provides a useful corrective in this respect and simultaneously alleviates many of the fears voiced by some observers relating to the alleged 'sell-out' affecting universities. As opposed to a 'sell-out', we found strong evidence that universities managed to retain their distinct identity as organizations governed by the 'republic of science'.

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Tables and Figures

Table 1. Proportion of respondents who assessed incentive items as very or extremely important (4 or 5 on five-point Likert scale)

	CHNG	CHEM	CIVG	COMP	ELEC	GENG	MATH	MENG	MANG	PHYS	Total
1. Applicability of research	71.9	64.9	72.2	78.5	78.8	79.0	68.8	80.7	80.0	73.1	*74.5*
2. Research Income from industry	75.9	79.3	79.5	65.1	80.6	71.4	54.8	76.5	79.0	69.9	*74.4*
3. Research Income from Gov.	71.4	58.6	76.8	75.0	79.0	76.5	62.9	75.8	80.0	61.2	*70.8*
4. Information on industry problem	77.2	53.7	79.5	65.7	70.3	75.3	66.2	78.9	70.5	54.8	*67.8*
5. Feedback from industry	42.1	44.2	62.0	53.3	67.1	58.6	36.5	58.0	49.2	46.2	*52.7*
6. Information on industry research	41.1	36.3	50.7	41.3	52.1	45.5	32.8	51.6	52.5	47.1	*45.0*
7. Access to materials	43.1	30.8	50.0	41.5	48.6	43.9	20.6	45.7	47.5	43.1	*41.2*
8. Becoming part of a network	42.6	29.9	45.8	24.5	33.6	38.3	27.4	41.9	38.6	32.7	*34.8*
9. Access to research expertise	34.5	29.6	22.2	31.4	35.4	30.6	22.6	34.8	33.9	35.0	*31.5*
10. Access to equipment	19.3	22.2	18.3	10.4	35.7	25.5	9.7	23.0	15.5	25.2	*22.0*
11. Source of personal income	17.2	12.2	15.5	31.1	15.7	11.1	26.2	11.2	15.3	15.8	*16.1*
12. Seeking IPR	8.8	13.3	10.0	5.8	11.3	12.4	3.2	9.9	5.2	21.6	*11.0*
*Number of observations**	*58*	*209*	*73*	*107*	*146*	*100*	*66*	*163*	*62*	*104*	*1088*

Notes: Abbreviations: CHNG, Chemical Engineering; CHEM, Chemistry; CIVG; Civil Engineering; COMP, Computer Science; ELEC, Electrical and Electronic Engineering; GENG, General Engineering; MATH, Mathematics; MENG, Mechanical, Aeronautical and Manufacturing Engineering, MANG; Materials and Metallurgy; PHYS, Physics.

* The total number of observations slightly varies across items due to missing responses.

Table 2: Summary of factor analysis results

Motivational items	**Motivation**
Source of personal income	Commercialization
Seeking IPRs	
Information on industry problems	
Feedback from industry	
Information on industry research	Learning
Applicability of research	
Becoming part of a network	
Access to materials	
Access to research expertise	Access to in-kind resources
Access to equipment	
Research income from industry	Access to funding
Research income from Gov.	

Table 3.Relationship between frequency of interaction and motivations
Ordered Logistic Regressions. Dependent variables: frequency of engagement in five channels

	Joint Research	Contract Research	Consulting	Spin-offs	Patents
Commercialization	0.020	0.042	0.559 ***	0.488 ***	0.758 ***
	(0.074)	(0.071)	(0.077)	(0.102)	(0.087)
Learning	0.265 ***	0.276 ***	0.177 *	0.197	-0.019
	(0.088)	(0.093)	(0.094)	(0.139)	(0.109)
Funding Resources	0.129 *	0.299 ***	0.133 *	0.039	0.037
	(0.068)	(0.076)	(0.075)	(0.106)	(0.092)
In-kind Resources	0.091	-0.231 ***	-0.196 **	-0.349 ***	-0.204 **
	(0.068)	(0.071)	(0.077)	(0.108)	(0.085)
N. Joint publ. (ln)	0.102	0.178 *	0.083	0.275 **	0.195 *
	(0.099)	(0.098)	(0.098)	(0.130)	(0.107)
N. Collab. Gr. (ln)	0.059 *	0.041	0.059 *	0.099 **	0.032
	(0.033)	(0.033)	(0.034)	(0.047)	(0.037)
Age	-0.021 **	-0.003	-0.018 **	0.009	0.007
	(0.009)	(0.009)	(0.008)	(0.012)	(0.010)
Professor status	0.581 ***	0.441 **	0.438 **	0.407 *	0.291
	(0.183)	(0.177)	(0.173)	(0.243)	(0.205)
Industry inc/staff (ln)	0.164	0.305 **	-0.088	0.064	0.227
	(0.126)	(0.122)	(0.134)	(0.175)	(0.149)
Public inc/staff (ln)	-0.234 *	0.122	-0.039	-0.097	0.299 *
	(0.141)	(0.142)	(0.162)	(0.216)	(0.181)
Dept. staff (ln)	0.027	0.129	0.192	0.025	0.005
	(0.139)	(0.144)	(0.154)	(0.187)	(0.165)
RAE 2001 Low	-0.037	0.276	0.363 **	-0.077	0.149
	(0.179)	(0.183)	(0.185)	(0.267)	(0.210)
RAE 2001 High	-0.085	-0.052	0.163	0.119	-0.119
	(0.182)	(0.191)	(0.195)	(0.269)	(0.223)
Chemistry	---	-0.644 ***	-0.681 ***	---	0.799 ***
		(0.242)	(0.251)		(0.285)
Civil Engineering	-0.717 ***	---	---	---	---
	(0.278)				
Computer Science	---	-1.223 ***	-1.482 ***	---	---
		(0.296)	(0.332)		
Electric & Electronic Eng.	---	---	-0.995 ***	---	0.909 ***
			(0.255)		(0.296)
General Engineering	---	-0.641 **	---	---	0.669 **
		(0.271)			(0.321)
Mathematics	-0.849 **	---	---	---	---
	(0.399)				
Physics	---	-0.747 **	-0.976 **	---	---
		(0.369)	(0.387)		
Prob.	0.688	0.505	1.439 **	-0.298	1.435 **
	(0.584)	(0.573)	(0.579)	(0.849)	(0.677)
Threshold / Cut point 1	0.986	2.393 **	2.745 ***	3.444 ***	5.418 ***
Region dummies	Included	Included	Included	Included	Included
Number of observations	960	964	966	964	959
Log Likelihood	-918.2	-902.0	-870.9	-469.7	-671.6
Restricted Log Likelihood	-973.3	-991.6	-975.9	-511.4	-765.6
Pseudo R^2 Nagelkerke	0.13	0.19	0.23	0.13	0.22

Note: Two tailed t-test: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. Robust standard errors between brackets. For discipline dummy variables, only significant coefficients are shown in the table.

Appendix

Table A1: Descriptive statistics for dependent variables

Dependent Variables	Average	St. Dev.	Min.	Max.	% Observations Category ‘0’	% Obs. Category ‘1’	% Obs. Category ‘2’	Number valid Obs.
1. Joint Research	0.79	0.70	0	2	37.2	47.1	15.8	1079
2. Contract Res.	0.85	0.70	0	2	33.5	48.5	18.1	1085
3. Consulting	0.68	0.71	0	2	46.6	38.8	14.6	1087
4. Spin-offs	0.19	0.43	0	2	82.9	15.3	1.8	1085
5. Patenting	0.29	0.56	0	2	68.9	23.7	7.4	1079

Table A2: Descriptive statistics and correlation matrix for explanatory and control variables

	Ave.	St. Dev.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12
1. Commercialization	2.04	0.91	1	5												
2. Learning	3.50	0.85	1	5	**0.24**											
3.Funding resources	3.97	0.94	1	5	**0.13**	**0.28**										
4. In-kind resources	2.78	1.06	1	5	**0.19**	**0.48**	**0.22**									
5. Ln Joint Pub	0.52	0.73	0.0	3.81	0.01	0.02	**0.11**	0.04								
6. Ln Coll. Grant	2.86	2.47	0.0	7.60	0.02	0.06	**0.15**	**0.09**	**0.07**							
7. Age	45.9	9.86	27	75	-0.05	0.04	0.05	-0.01	**0.16**	**0.27**						
8. Professor	0.53	0.50	0.0	1	-0.02	-0.02	**0.09**	-0.03	**0.22**	**0.26**	**0.59**					
9. Indu. Inc./staff	1.61	0.78	0.0	3.53	-0.04	0.05	**0.13**	0.02	**0.12**	**0.11**	0.01	-0.01				
10. Pub. Inc./staff	2.61	0.70	0.0	4.33	-0.01	**-0.08**	-0.01	0.02	**0.14**	**0.11**	-0.01	0.05	**0.34**			
11. Ln Staff	4.22	0.68	2.07	5.53	0.01	-0.04	-0.02	0.01	**0.09**	**0.07**	0.01	0.02	**0.42**	**0.37**		
12. Low RAE	0.31	0.46	0	1	0.02	**0.07**	**0.07**	0.02	-0.04	**-0.09**	-0.01	**-0.06**	**-0.12**	**-0.36**	**-0.41**	
13. High RAE	0.30	0.46	0	1	-0.01	-0.05	-0.03	0.01	**0.07**	**0.08**	**0.06**	**0.07**	**0.20**	**0.36**	**0.43**	**-0.43**

Correlation coefficients significant at the 0.05 level, in bold.

Table A3: Factor analysis results: Incentives for interacting with industry

	Mean	St. Dev.	Factor 1	Factor 2	Factor 3	Factor 4
Source of personal income	2.04	1.25	-0.032	-0.079	-0.001	**0.896**
Seeking IPRs	2.05	1.11	0.324	0.340	0.105	**0.521**
Information on industry problems	3.87	1.07	**0.800**	0.079	0.160	-0.033
Feedback from industry	3.41	1.19	**0.721**	0.220	0.080	0.081
Information on industry research	3.26	1.21	**0.656**	0.303	0.216	0.012
Applicability of research	3.99	1.05	**0.764**	0.044	-0.015	0.075
Becoming part of a network	2.94	1.21	**0.625**	0.288	0.016	0.064
Research income from industry	4.01	1.12	0.064	-0.001	**0.831**	0.178
Research income from government	3.93	1.16	0.159	0.172	**0.772**	-0.121
Access to materials	3.03	1.35	0.193	**0.735**	0.047	0.020
Access to research expertise	2.83	1.23	0.254	**0.812**	0.011	-0.036
Access to equipment	2.48	1.48	0.127	**0.821**	0.155	0.082
Rotation sums of squared loadings			2.82	2.26	1.40	1.15
Proportion of variance explained (%)			23.48	18.81	11.69	9.55
Cumulative proportion of variance explained (%)			23.48	42.29	53.98	63.53

Table A4: Relationship between frequency of interaction and motivations

Results of multivariate probit analysis. Dependent variables are dichotomous taking the value of 1 if the degree of engagement is above the median for a given engagement channel (and 0 otherwise)

	Joint Research (3 times or more)	Contract Research (3 times or more)	Consulting (3 times or more)	Spin-offs (at least once)	Patents (at least once)
Commercialisation	-0.008	0.036	0.281 ***	0.288 ***	0.451 ***
	(0.062)	(0.062)	(0.062)	(0.055)	(0.054)
Learning	0.219 ***	0.163 **	0.152 *	0.086	-0.005
	(0.077)	(0.076)	(0.080)	(0.071)	(0.066)
Funding Resources	0.096	0.225 ***	0.001	0.019	0.062
	(0.066)	(0.067)	(0.066)	(0.059)	(0.055)
In-kind Resources	0.048	-0.137 **	-0.146 **	-0.195 ***	-0.113 **
	(0.058)	(0.058)	(0.061)	(0.056)	(0.050)
N. Joint publ. (ln)	0.121	0.097	0.057	0.116	0.100
	(0.077)	(0.077)	(0.082)	(0.075)	(0.067)
N. Collab. Gr. (ln)	0.066 **	0.033	0.047	0.053 **	0.009
	(0.028)	(0.028)	(0.030)	(0.027)	(0.024)
Age	-0.018 **	-0.002	-0.021 ***	0.004	0.004
	(0.007)	(0.007)	(0.008)	(0.007)	(0.006)
Professor status	0.372 **	0.283 *	0.322 **	0.201	0.124
	(0.146)	(0.146)	(0.155)	(0.139)	(0.126)
Industry inc/staff (ln)	0.089	0.189 *	-0.041	0.017	0.064
	(0.101)	(0.107)	(0.109)	(0.097)	(0.090)
Public inc/staff (ln)	-0.119	0.114	-0.117	-0.081	0.145
	(0.113)	(0.126)	(0.117)	(0.106)	(0.106)
Dept. staff (ln)	0.038	0.184	-0.019	-0.032	-0.004
	(0.109)	(0.114)	(0.114)	(0.106)	(0.097)
RAE 2001 Low	0.049	0.205	0.241	-0.084	0.054
	(0.147)	(0.149)	(0.156)	(0.142)	(0.128)
RAE 2001 High	0.035	0.109	0.405 **	0.091	-0.032
	(0.153)	(0.154)	(0.164)	(0.147)	(0.135)
Prob. (formal interaction)	-0.001	0.336	0.906	0.039	0.869 *
	(0.553)	(0.573)	(0.656)	(0.488)	(0.455)
Intercept	-1.753 **	-3.879 ***	-1.366	-1.686 **	-3.022 ***
Reg. & Discipline dummies	Included	Included	Included	Included	Included

	Rho1	Rho2	Rho3	Rho4
Rho2	0.435 (0.064)			
Rho3	0.349 (0.072)	0.389 (0.068)		
Rho4	0.374 (0.067)	0.176 (0.075)	0.082 (0.076)	
Rho5	0.257 (0.065)	0.207 (0.066)	0.086 (0.072)	0.551 (0.052)
Observations	945			
LL	-1894.5			
LL_0	-1989.8			
Wald $\chi^2(160)$	433.4			

Note: Two tailed t-test: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. Standard errors between brackets. All regressions include discipline dummies.